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Compressive Behavior of Interlocking Plastic Block Structural Elements

by

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I want to dedicate this research towards my friends, teachers and my parents who helped me throughout my education.

CERTIFICATE OF APPROVAL

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Abstract

Earthquake is one of the natural catastrophes that are dangerous and life threatening. Earthquakes have various damaging effects on the areas in which they occur. This cause damage to infrastructure, and the loss of human life in the worst situations. Masonry houses, in particular, are a threat to human life in seismic zones in rural and urban regions worldwide. Strong earthquakes generates ground movements which severely damage the masonry structures. Affordable earthquake resistant housing in earthquake prone areas is demand of time.

Researchers have studied several interlocking methods that are free from mortar, but interlocking plastic block structures are still not being investigated. To start with, prototype interlocking plastic block unit, prisms, column, solid wall and wall with window opening are considered for making the mortar-free structure. In this study, behavior of interlocking plastic block unit, prisms, column, solid wall and with window are investigated against compressive loading under servo-hydraulic testing machine in laboratory.

The compressive behavior of individual and multiple standard blocks, column, solid wall and wall with window opening is investigated in terms of stress-strain curve, energy absorption and toughness index. Correlations between compressive strength of interlocking plastic block unit and structural elements are developed. The total compressive toughness of multiple blocks is less than that of an individual block and total compressive toughness of walls is greater than column. Prototype interlocking plastic block solid wall depicted more resistant to compressive load than wall with window opening. The correlations among the interlocking plastic individual block (f_{1b}), prism having two blocks (f_{2b}), prism having three blocks (f_{3b}), column (f_{cb}), solid wall (f_{sw}) and wall with opening (f_{wo}) found in this analysis are $f_{2b} = 1.6f_{1b}$, $f_{3b} = 1.2f_{1b}$, $f_{cb} = 0.96f_{3b}$, $f_{sw} = 2.2f_{cb}$ and $f_{wo} = 0.5f_{sw}$. This study can be used to further understand the in depth behavior of interlocking plastic block capacity in future.

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Abbreviations

1 D	One Dimensional
3 D	Three Dimensional
IPBSW	Interlocking Plastic-block Solid Wall
IPBWO	Interlocking Plastic-block Wall With Opening
kN	kilo-Newton
MPa	Mega Pascal
Nm	Newton meter
P	Peak Load
TI	Toughness Index

Symbols

E_1	Energy absorption before cracking
E_2	Energy absorption after cracking
f_{1b}	Peak load capacity of interlocking plastic block unit
f_{2b}	Peak load capacity of interlocking plastic block prism having two blocks
f_{3b}	Peak load capacity of interlocking plastic block prism having three blocks
f_{cb}	Peak load capacity of interlocking plastic block column
f_{sw}	Peak load capacity of interlocking plastic block solid wall
f_{wo}	Peak load capacity of interlocking plastic block wall with opening

Chapter 1

Introduction

1.1 Background

An earthquake is the natural disaster which produce strong ground motion. Primary effects of an earthquake cause severe damages, such as collapse of building, roads and bridges, which may kill many people. Specifically, masonry buildings in seismic zones of rural and urban regions throughout the world poses severe threat to human life. Because strong ground motions generated by earthquake badly damage the masonry structures. More than 450,000 buildings were damaged during the 2005 Kashmir earthquake. Earthquake can also cause floods and landslide. Buildings can collapse when soil have high water content, because soil having high percentage of water content behaves like fluid and lose their mechanical strength when soil shake violently. Earthquake happens beneath the ocean floor can lead towards tsunami. Most of structures are often effected during intense earthquake and collapse. Earthquake badly affects masonry structure due to strong ground motion.

In seismic active region, the economical earthquake resistance housing in rural areas of developing counties is desirable. These areas also experience a severe loss of life during heavy ground motion due to the lack of seismic resistance in the building. A new construction technique have been explored using structure consisting of interlocking plastic blocks to make a cost-effective solution. Interlocking plastic block used in structure plays an important role during strong ground motion. These interlocking plastic blocks dissipate more energy during seismic event, because of the relative movement at the block interfaces. During the earthquake of 2005 in Kashmir more than 4,50,000 buildings were partially or fully damaged in Kashmir [1].

During earthquake, acceleration is produced which enters from ground to foundation of structure causes shearing of masonry structure due to inertia. Recently, earthquake in 2018 in Indonesia damages more than 1000 houses. In earthquake, most of the masonry structures collapsed because of design deficiencies [2]. An effort is required to reduce losses during future earthquake.

Ali [3] proposed mortar free structure (a new construction technique) for earthquake resistant housing. A mortar-free interlocking block structure has the ability to dissipate energy of earthquake. Lighter the mass of structure, lower the inertial force generated. For this, light weight interlocking plastic block is one solution. There is need to reduce mass of block in order to reduce inertial forces. Interlocking block is one option to explore. Mohammad (2005) tested wall panels made of gypsum cement and coconut fibre. Ali [4] tested compressive strength of interlocking blocks using compressive testing machine in the laboratory. Servo-hydraulic testing machine can be used to understand the compressive strength behavior of interlocking blocks made up of plastic.

The compressive strength (compressive capacity) of unit block, prism having two blocks, prism having three blocks, column having eight blocks (vertically), solid wall having forty eight blocks and wall with window opening having forty two blocks are determined using standard procedures. All the samples are tested in a servo-hydraulic testing machine to determine peak load, stress, corresponding strain, modulus of elasticity, compressive strength, energy absorption before cracking, energy absorption after cracking and total compressive toughness. After that correlations of compressive capacity have been made among standard block unit, prisms, column, solid wall and wall with opening. [To the best of author knowledge, no study has been conducted to investigate the behavior of interlocking plastic-block structure under compressive load using servo-hydraulic testing machine.]

1.2 Research Motivation and Problem Statement

Earthquake causes severe damage, such as collapse of buildings, roads and bridges, which may kill many people. Such losses can be reduced if precise behavior of structures is studied which can help in its proper design. Developed countries have such facilities but developing countries are lacking these facilities. Ali. M [3] proposed an economical solution but the mass of block still needs to be reduced. Interlocking plastic-block structure can be one option with consideration of fire-resistant paint. For economical and environmental aspects, plastic waste can be recycled for this purpose (note: for the time being, it is outside the scope of this work). Thus the problem statement is as follows;

In earthquake, most of the masonry structures collapsed due to design deficiencies [4]. Ali. M [3] developed a mortar free structure (a new construction technique) for earthquake-resistant housing. A mortar-free interlocking plastic-block structure has the ability to dissipate energy of earthquake. Lighter the mass of structure, lower the inertial force generated. For this, light weight interlocking plastic-block is one solution along with fire-resistant paint. For such kind of structure (i.e mortar-free interlocking plastic block structure), compressive behavior should be studied. This can be done with servo-hydraulic testing machine.

1.2.1 Research Questions

How can the correlation of compressive strength between interlocking plastic block unit and structural elements be helpful in practical implementation?

What is the use of determination of compressive strength of interlocking plastic blocks walls in practical life?

1.3 Overall Objective of Research Program and Specific Aim of this MS Thesis

The overall objective of the research program is to precisely investigate the compressive strength behavior of full scale structure in laboratory and field. The specific aim of this MS research work is to investigate the compressive strength of a prototype interlocking plastic-block structure using servo-hydraulic testing machine in laboratory.

1.4 Scope of Work and Study Limitations

Prototype interlocking plastic-block unit, prisms with multiple blocks, column, solid wall and wall with opening. Interlocking plastic block unit and structural elements are placed in servo-hydraulic testing machine. Loadings at standard rates are applied. Response in terms of compressive strength, stress and strain are recorded. Correlation between compressive capacity for these are developed. Study limitation include the use of servo hydraulic testing machine.

1.4.1 Scope of Work and Study Limitations

The justification behind specified selections are:

- Because of their regular usage in home, solid wall and wall with opening are chosen.
- Only the elevation measurements are scaled down by 1/10 due to UBC-97 method A, which depends on the height of the column.
- Simple boundary condition is known to study the compressive behavior of walls.

1.5 Brief Methodology

Uniaxial compression test is performed on interlocking plastic block unit, prisms having multiple blocks, column, solid wall and wall with window opening made of interlocking plastic units. Prisms consisting of two and three interlocking plastic block units, column having eight block and wall systems, namely solid wall and wall with window opening are constructed. The compressive strength of interlocking plastic blocks is obtained by using the servo-hydraulic testing machine and the requirements of ASTM D695-02a are fulfilled to conduct the tests. In order to prevent any local failure of interlocking plastic blocks and to distribute the applied load uniformly, samples are centrally put in the servo-hydraulic testing machine and capped at the top and bottom of the face shells by steel plates. The speed of servo-hydraulic testing machine to compress sample is 0.05 in/min until failure. Based on the bearing area, the compressive capacity, energy absorption and toughness index of the integrated plastic units are then calculated. Interlocking plastic block unit and prism comprises of two and three units are tested against compressive loading in servo-hydraulic testing machine. The tested column is consisted of eight units block and its total height is 330 mm. The tested solid wall consists of forty eight interlocking blocks and wall with opening consists of forty two inter-locking plastic blocks making a total height (H) of 330 mm. The wall with opening is having an opening in the form of window in the middle. The dimensions of opening are 125 mm x 185 mm. Wooden lintel is provided above the opening for support mechanism. In addition, rubber band are tied up from bottom to top through mid of blocks to provide vertical stiffness in interlocking plastic block unit, prisms, column and walls. Fixed base with the help of steel plates is provided.

1.6 Thesis Outline

There are six chapters in this thesis, which are as follows:

Chapter 1 consists of introduction section. It includes background, research motivation, problem statement, overall objective, specific aim, scope of work, study limitations, methodology adopted to conduct the study, and thesis outline.

Chapter 2 contains the literature review section. It consists of background, damages of conventional masonry structures during earthquake, new approach for earthquake-resistant structures, compressive behavior of prototype structures in lab, and summary.

Chapter 3 consists of experimental program. It contains background, technique to construct interlocking plastic block unit, prisms, solid wall and wall with window opening, test setup of servo-hydraulic testing machine with instrumentation, application of compressive loading, analyzed parameters, , development of correlations, and summary.

Chapter 4 consists of experimental evaluation. It contains background, compressive testing, response of block unit, prisms, column, solid wall and wall with window opening, calculation of compressive strength, energy absorption, toughness index and summary.

Chapter 5 comprise of discussion. It contains background, correlations between compressive capacity, outcome of study with respect to practical requirements, and summary.

Chapter 6 includes conclusion and recommendations. References are presented right after chapter 6. Annexures are given at the end.

Chapter 2

Literature Review

2.1 Introduction

Earthquakes produce various damaging effects on the zones on which they occur. Masonry buildings, in particular, are a hazard to human life in seismic zones of rural and urban regions throughout the world. Ground acceleration is transferred from ground to foundation of structure which causes inertia to damage the masonry walls. The literature indicates that various building techniques have been adopted in the form of structural components to build earthquake-resistant masonry buildings. One new earthquake-resistant technique is the construction with interlocking blocks. But the bigger inertial forces due to the greater mass of these conventional building blocks are a problem. This chapter includes the literature review about impacts of conventional masonry structures during earthquake, new approach for structures resistant to earthquakes and compressive performance of interlocking blocks.

2.2 Impacts of Earthquakes on Masonry Structures

Many researchers has noted the collapse of traditional buildings made of masonry in the form of various failures. Graziotti et al. [5] has been reported that some 0.8

million buildings collapsed completely or partially due to Gorkha earthquake in 2015. A major seismic event followed by a large aftershock hit the city 's entire hilly area, resulting in the collapse of many buildings made of brick masonry. Zhao et al. [6] studied that almost 4,50,000 buildings were damaged, almost 75000 people died, almost 69000 people were injured and about 2.8 million people were lost their shelter in October, 2005 earthquake. 87,476 and 731 peoples lost their lives, 459,76,596 and 11,20,513 people were injured and there was an economic loss of 852.309 and 19.849 billion in wenchuan and ludian earthquake china respectively. Most of the masonry structures collapsed during earthquake due to deficiencies in design Arya et al.[7]. Several people died, injured and remained homeless until rescue operations were done by the governing authorities there. Besides that, from this disaster, the country was faced with a huge economic loss.

Different brick masonry failures were recorded in the form of vertical cracks near the corner, cross cracks initiated from the edges of the openings, plane failure, and gable wall failure and wall separation vertically and opening in short walls. Poor construction practices, poor use of materials, undesigned structures, unconfined gable walls and cracking from the edges of the openings were the main reasons behind these brick masonry failures. It had been proposed that vertical and horizontal bands should be strengthened or supported for the retrofitting of partially damaged masonry houses. Jagadish et al. [8] reported that the traditional masonry structures suffered considerable damage during the January 2001 Bhuj earthquake. Many of the buildings made of masonry had zero earthquake-resistant properties that caused significant damage to these buildings. Out-of-plane collapse, fractures beneath bands, out-of-plane wall failure leading to lintel band collapse were more frequently observed defects in the masonry structures. The primary cause of these failures was the use of mud mortar or lime mortar which resulted in weak bond strength. In case of cement mortar was used in masonry, bond strength was not enough to withstand the earthquake vibrations. The most common issue was brick masonry wall failure in the form of cracks under the lintel beam and lintel band failure. Properly constructed brick masonry wall with horizontal / vertical bands with corner reinforcement properly resists earthquake shaking. It was found during the survey that lintel bands were not properly constructed and there was lack of longitudinal strengthening. The study indicated that while the horizontal

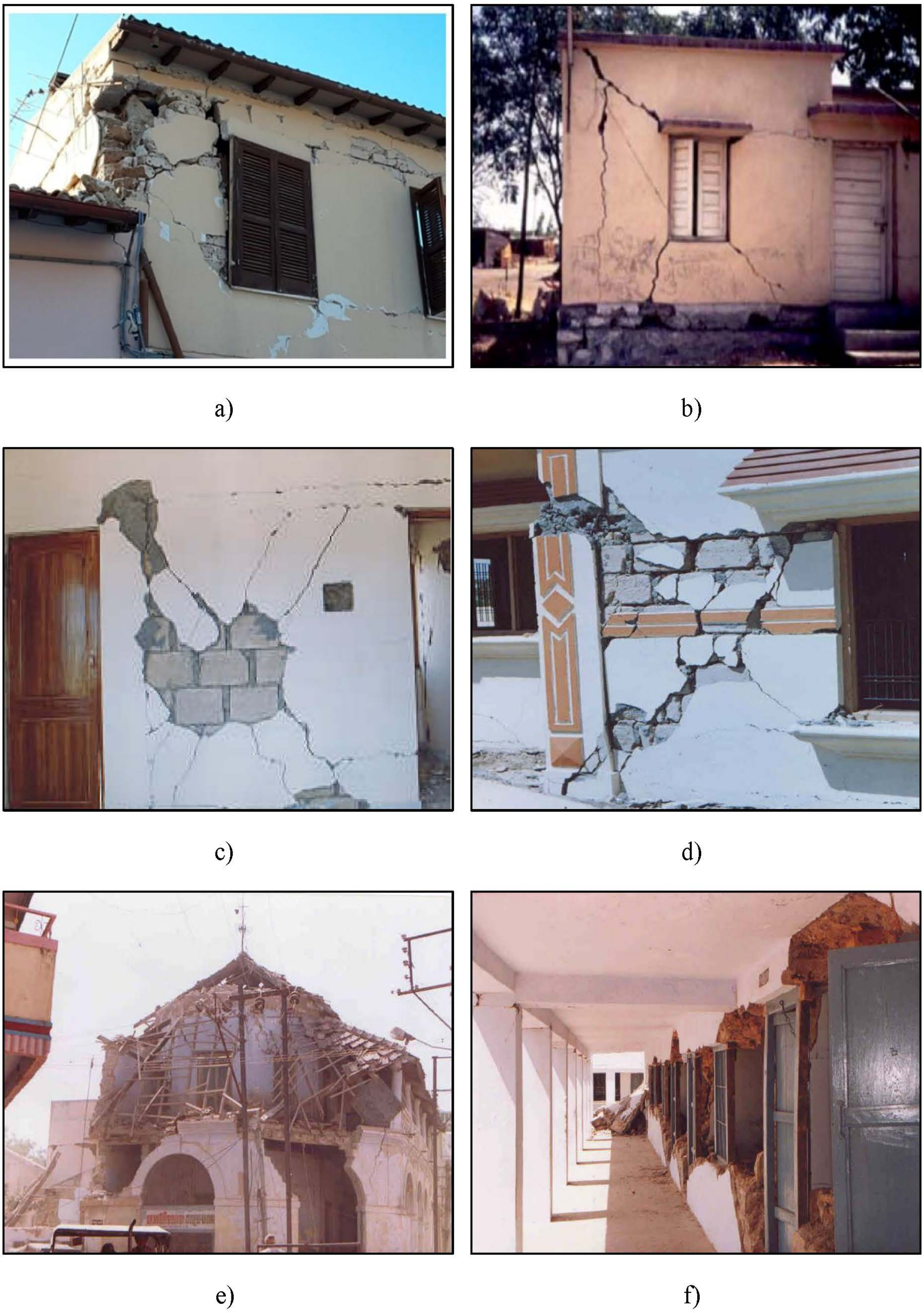


FIGURE 2.1: Conventional masonry failures; a) Cracks in bed joints b) Shear cracks c) Failure due to out-of-plane vibration d) Separation of corner column e) Out-of-plane collapse of sandstone in lime mortar masonry wall f) Collapse of walls between openings.

bands decrease the in-plane shear and vertical cracks, they may not be useful in case of out-of-plane flexure failure.

Yon et al. [9] reported that, on 24 August 2016, the effect of the two seismic events on Amatrice district was unusually catastrophic. There had been 298 fatalities, 386 people had been injured, about 5000 homeless people and significant destruction of the ancient hub of the town. The European Macro-Seismic Scale (EMS-98), based on an evaluation report undertaken in September 2016, explained the deterioration trends of the systems in the ancient center of the city. The level of damage was found to be extremely high with more than 60 percent of the investigated structures showing minor or complete failure. The high degree of damage was caused by the excessive inefficiency of the masonry systems due to improper use of the material, the absence of connections with the walls and the inappropriate relationship with walls and floors.

There were no demolition operations going on prior to the start of the dismantling process. It was also important to ascertain the exact causes of the failure as well as to include information about the moment that the tragedy happened. As a result of the studies and observations carried out, it was quantitatively identified and verified that when planning openings for shop windows in the non-homogeneous structure of the wall, the key causes of the building collapse were faults. The most critical problem, though, was the mortar flaws linking the wall's ceramic components. For both the static case of leaning buttresses and the dynamic case of horizontal acceleration, the collapse mechanisms are established. This study showed that, in most situations, the structure collapsed and the buildings remained upright. New approaches were proposed on the basis of these factors to test the protection of masonry systems and decided the effect of potential movements on structures. The earthquake had caused significant damages to a masonry structure. Su et al. [10] had described the damage of buildings based on the damage survey to the Tohoku earthquake. Masonry buildings were severely damaged by the earthquakes. More than 450,000 buildings were damaged during the 2005 Kashmir, Pakistan earthquake. In 2008 Sichuan, China's earthquake of greatest magnitude resulted collapses of 216,000 buildings and the death of 70,000 people. In 2010, Haiti earthquake having a magnitude of 7.00 resulted the death of 316,000 human beings and more than 300,000 people were injured. The Haitian government was proclaimed that 80 to 90 percent brickwork structure fundamentally destroyed. During the Maule seismic event of 2010, 80,000 people were injured and 524 deaths of people were occurred. In the recent years, many countries were faced serious damage to masonry buildings.

Table 2.1: Earthquakes and their damages

Sr. No.	**Location**	**Year**	**Magnitude**	**Deaths**	**Comments**
1	Tohoku, Japan	2011	9.03	15,878	After WWII, Japan's most challenging crisis, which destroyed more than 129,225 houses, triggered fires and tsunamis as well.
2	Sichuan, China	2008	8.0	69,197	It rendered almost 15 million people homeless and caused $146.5 billion economic loss.
3	Kashmir, Pakistan	2005	7.6	73,000	Due to poor construction of work, there is US$5.2 loss by damages of 400,000 structures partly or fully
4	Izmit, Turkey	1999	7.6	45,000	The absorb frequencies by buildings are more than their capacity due to lack of design, in return there is many losses of properties and life.

The study indicated that the role of successful engineering evaluations in the presence of current buildings in construction is very significant, and that traditional

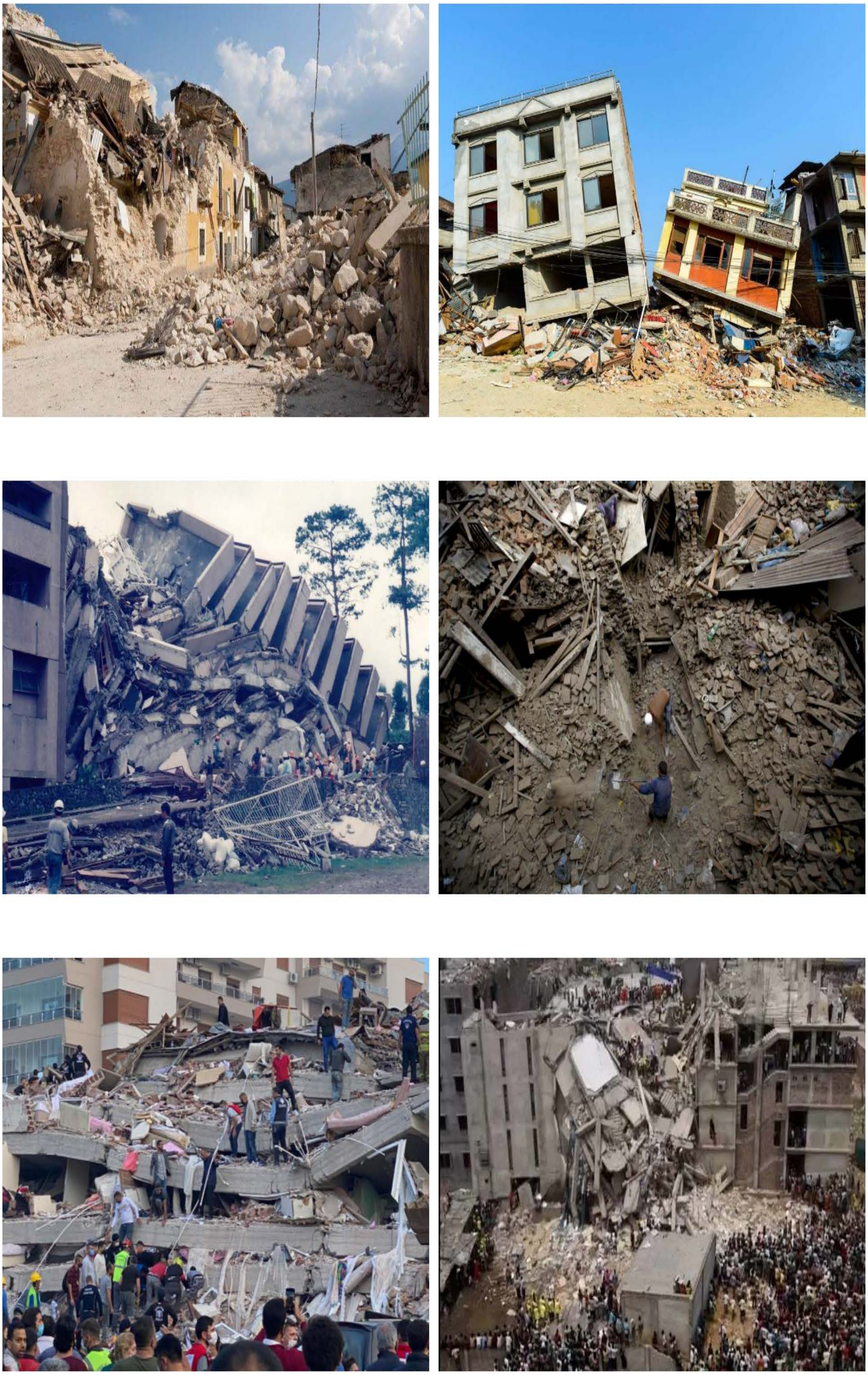


Figure 2.2: Masonry structures damages during earthquakes.

methods alone can not be achieved. Perhaps, it requires a point-to-point evaluation of the local and global actions of the building, along with content testing. Yn et al. [9] investigated the collapse of the masonry system during high-intensity earthquakes triggered by Anatolian fault line in eastern Turkey. For future studies, they also provided explanations of failure, updated data on active fault regions and seismic maps. Equally, during the 2015 Gorkha earthquake, old masonry buildings suffered significant loss. Su et al . [10] considered damage to buildings made of masonry during the 2008 Wenchuan earthquake. A significant seismic event accompanied by a large aftershock shooting the entire city, resulting in the collapse of several brick masonry buildings. Several residents died, injured and remained homeless until they were saved by the rescue operation performed by governing authorities. Besides that, this disaster had left the world suffering a huge economic loss. Several masonry structures have been reported to fail in the form of cross-cracks between openings, diagonal cracks initiated from openings. Poor building methods, improper use of materials and undesigned building walls were the key reasons behind these brick masonry failures.

2.3 New Approach for Structures Resistant to Earthquakes

Because of the strong demand for high efficiency, time and cost-saving construction methods, over the last few decades, significant improvements have been made to the traditional masonry method. Researchers have made considerable efforts to build an interlocking mortar-less masonry framework in order to make construction of masonry more economical and sustainable than the typical masonry system. Tang et al. [4] studied residual compressive and shear strengths of novel coconut fibre reinforced concrete interlocking blocks. In order to remove the settling mortar Fay et al. [11] developed revolutionary interlocked soil-cement blocks for masonry construction. Various mortarless (dry-stack) interlocking bricks, including ”Sparlock system, Meccano system, Sparfil system, Haener system, and Solid Interlocking blocks (SIB) or Hydraform blocks (SIB) have been developed globally Anand and Ramamurthy [12]. Many techniques are available to build

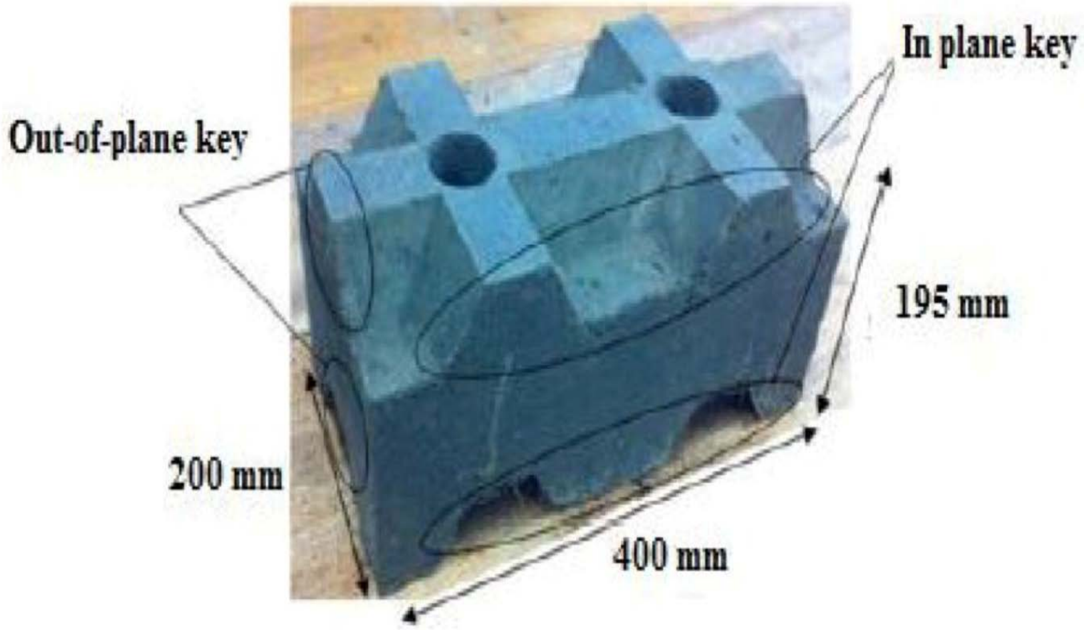


Figure 2.3: Coconut Fibre Reinforced Concrete (CFRC) interlocking block.

earthquake-resistant homes. However, most of them are too costly for most individuals, particularly those living in developing and under-developed nations. Also the construction procedures available are too complex. People are not employing skilled labour in rural areas. They also build non-engineered buildings on their own, just to minimize construction costs. They also simply embrace old conventional construction methods that are not resistant to earthquake, resulting in failures and eventually causing casualties and financial losses by Fakih et al.[13].

A number of large earthquakes in the past (e.g. earthquake in Nepal in 2011, earthquake in Haiti in 2010, earthquake in Pakistan in 2005 and earthquake in Sumatra(2004) clearly demonstrates the need to establish new construction technologies for implementation in earthquake-prone regions. It should be open to ordinary citizens so that, with the local resources available and little guidance, they can build their own homes. Naturally, the cost of material reinforcement would be minimized if local resources were used. Using interlocking blocks is one choice. On the other hand, using more natural, advanced and environmentally friendly materials to build interlocking masonry bricks will make a greater duty to protect the environment and sustainable development. Different types of waste materials such as reinforced coconut fiber concrete, geopolymer, soil cement, fly ash, alkali-activated fly ash and stabilized mud-fly ash were converted into a

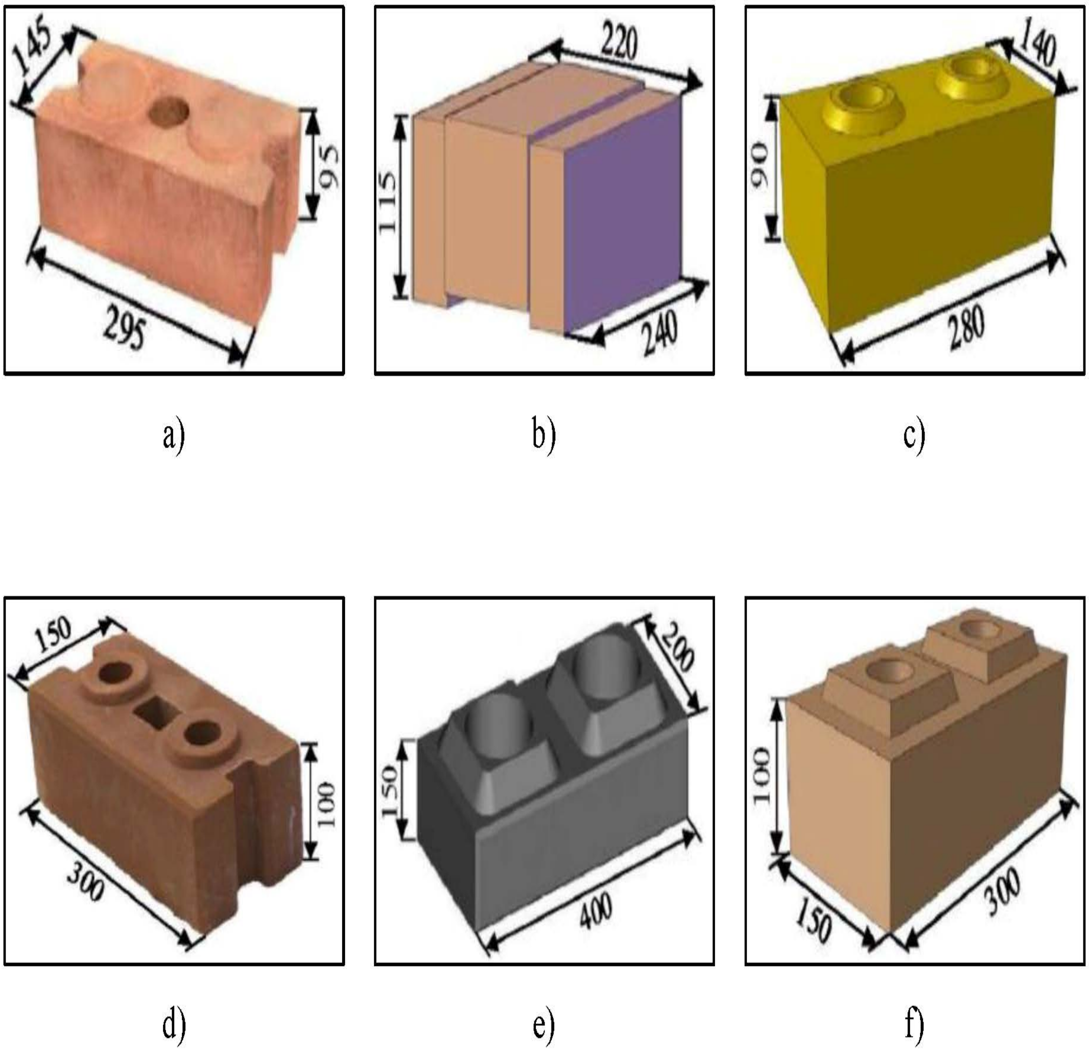


Figure 2.4: Various interlocking earth blocks; a) Auram interlocking block b) Hydraform interlocking block c) HiLoTec interlocking block d) Thai Rhino interlocking block e) Hollow interlocking block f) Tanzanian interlocking block

new form of advanced brick ash for the masonry Mohammad et al. [20]. These innovative bricks/blocks vary in size, making them suitable for load-bearing or non-load-bearing wall structures. Furthermore, the interlocking mechanism improves the brick unit's stability, improving the horizontal and vertical alignment of the designed wall to withstand loads such as wall systems without mortar. The absence of the mortar in the bed and head joints of the interlocking masonry wall, however, can lead to structural behavior that differs from that of conventional masonry wall under axial compression and horizontal loads. Fundi et al. [21] studied performance of interlocking laterite soil block walls under static loading. Martinez and Atamturktur [22] studied experimental and numerical evaluation of reinforced dry-stacked concrete masonry walls. Martinez and Atamturktur [22]

Table 2.2: Summarized details of various interlocking compressed earth blocks proposed in previous researches

Reference	**Interlocking-block Shape**	**Main Findings**
Qu et al. [14]	Thai Rhino block	Stress-strain curves of prisms; seismic performance of flexure-dominated interlocking compressed earth block walls; the structural performance of interlocking compressed earth block walls under cyclic in-plane loading.
Bland et al. [15]	Tanzanian block	Block irregularity and implication for wall quality; the relationship between alignment and block geometric imperfection; stiffness of the interlocking block columns.
Maini et al. [16]	Auram block	Dry compression, shear and bending compressive strength; absorption of water.
Uzoegbo et al. [17]	Hydraform block	Compressive strength of the masonry units; compressive strength of the dry-stack walls.
Fay et al. [18]	Hollow block	Resistance of compression, water absorption, and sizing of interlocking compressed earth blocks.
Sturm et al. [19]	HiLoTec block	Compressive and flexural strength of the units; compressive and shear behavior of masonry prisms.

studied experimental and analytical analysis of the load bearing capacity of improved dry-stacked masonry. Gelen Gael Chewe Ngapeya and Waldmann [23, 24] researched to overcome bed-joint imperfections and enhance real contact in dry-stacked masonry. Fakih et al. [25] studied the axial compression behavior of rubberized interlocking masonry walls in an experimental analysis.

In order to minimize construction time and the expense of buildings, researchers have also proposed the use of interlocking blocks to replace standard bricks, thus eliminating mortar from the construction of masonry as reported by Mohammed et al. [20]. Anand and Ramamurthy [12] compiled the history of interlocking blocks development till 2004 and explained geometry, purposes and construction methods of their shapes. Some other interlocking blocks were also built from 2004 until now. Most of these blocks are hollow Miranda et al. [26], some are solid Nazar and

Sinha [27] and curved Dedek, Claude, and Kumaran [28], and some with reinforcement holes. These blocks can be mechanically or manually prepared, but in some cases they require very complicated moulds and casting by hand. The material was usually concrete but stabilized soil and fly ash were used as well. These blocks also differ in thickness, making them ideal for load-bearing, partitioning, or wall cladding. For in-plane and out-of-plane directions, either horizontal, vertical or both interconnecting keys provide the interlocking mechanism. These blocks have the main purpose of making accurate alignment and quick construction.It should be mentioned that the interlocking keys of the hollow blocks alone are typically not adequate to withstand construction load stresses in an assembled wall structure due to the removal of mortar layers as reported by Ngapeya and Waldmann [23]. It may be because the key projection is limited. Standard reinforced concrete is used in the holes created in the hollow blocks at regular intervals to solve this issue. This makes the structure very uneconomic. Relatively less mortar is used with the interlocking blocks in some situations (compared to that required in normal brick masonry) Fundi et al. [21].

2.4 Compressive Behavior of Interlocking Blocks and Structural Elements

In the design of masonry structures, the compressive strength (compressive capacity) of masonry is the most significant parameter and depends primarily on the strength of the individual unit and the compressive strength of the walls as reported by Safiee et al. [29]. Several specifications and construction codes have tabulated masonry strength values that can be used to assess the strength of the wall. In the last few decades the performance of mortar-less masonry under compressive loading has been investigated by several researchers. When designing mortar-less wall panels made of interlocking hollow blocks, the wall strength capacity has to be evaluated. The compressive capacity of masonry is considered an important factor in the design of brick work structures and is primarily governed by the standard brick unit strength. Therefore, Jaafar et al. [30] used Putra interlocking hollow blocks to develop the hollow unit block (f_{cb}), prisms (f_{cp}) and walls

(f_{cw}) subjected to compressive load for load-bearing strength correlation. As a result, the relationship of compressive strength between the block unit (f_{block}) and the prism (f_{prism}) derived to be $f_{prism} = 0.47\ f_{block}$ and the correlation between the strength of the block unit and the wall panel f_{wall} derived to be $f_{wall} = 0.39\ f_{block}$ and finally the strength correlation between prism and wall derived to be $f_{wall} = 0.83 f_{prism}$.

Both standard specifications were met for interlocking behavior and block strength for load bearing. The residual compressive and shear strengths of new coconut fiber reinforced concrete (CFRC) interlocking blocks under dynamic loading have been evaluated by Ali [31]. Ahmad et al. [32] observed the compressive capacity of the wall made of concrete interlocking bricks with mortar and non-mortar paste. The results showed that the compressive capacity of interlocking concrete bricks with or without mortar met the minimum compressive capacity requirement required by BS3921:1985, which is 5.2 MPa for traditional concrete blocks. Ahmad et al. [32] concluded that compressive strength of interlocking concrete bricks with mortar paste was greater than that of conventional concrete blocks. Ahmad et al. [33] tested the compressive strength of the masonry wall made from interlocking bricks made from mortar-free concrete. Studies have shown that a mortar-free wall's inherent tension allows it to be used for residential buildings. Two methods have been introduced in order to determine the compressive strength of the masonry codes, specifications, and standards, namely unit prism strength method. However, the cracking pattern and the masonry wall panel's ultimate load-bearing capability are based on the geometry and their interfaces Sarhosis et al. [34]

2.5 Novelty of Current Study

Different analysis models were required to assess the compressive strength of masonry structures corresponding to unit and prism strength. A new construction technique of interlocking plastic block structure for earthquake-resistant houses has been investigated to empower the efficient and cost-effective solution for earthquake-resistant houses. There are, therefore, no codes of conduct to refer to. Furthermore, there is no specification or code available to equate the compressive strength of the interlocking wall with the prism or plastic block unit compressive strength. In this study, compressive behavior of interlocking plastic blocks unit, prisms, column, solid wall and wall with window opening has been investigated by using servo-hydraulic testing machine. The data obtained in the present study will therefore, provide a guide to the design of the interlocking plastic block wall, based on either the strength of individual unit or the strength of the prism. To the best knowledge of author, no study has been done to explore the compressive behavior of interlocking plastic blocks and structural elements under compressive loading by using servo-hydraulic testing machine. Hence, current research helps to understand the compressive behavior of interlocking plastic blocks and structural elements reinforced vertically with rubber band.

2.6 Summary

Conventional structures made of masonry are prone to earthquake. In their construction techniques modern countries have adopted the practice of confined masonry. But up to some degree these are also prone to earthquake vibrations. Researchers are focussing on interlocking blocks free of mortar as a substitute for brick masonry. For these blocks a lot of sizes, shapes and interlocking techniques have been featured in the available literature. Examining the compressive behavior of interlocking block prototype structures using the compression testing machine in the laboratory gives output to a higher level of precision. By conducting small scale testing, it is possible to better predict the behavior of these interlocking block prototypes against compressive loading. Their analytical validation can be used for the development of empirical relationships to perform simplified testing with percentage identification of error. Many researches support and validate the results obtained from the testing of these prototype structures. Most researchers have till now focused on studies of concrete blocks or blocks of masonry. However, the use of any other lightweight material can play a crucial role in reducing the inertial forces. Use of plastic-blocks for prototype wall interlocking is such an example of lightweight materials in this research.

Chapter 3

Experimental Program

3.1 Background

In chapter two, damages during earthquake, response of structure during real earthquake and new technology for earthquake resistant has been discussed. This chapter includes many topics such as proposed structure and plastic-block, compression testing of interlocking plastic bock, stress-strain curve of interlocking plastic-block, test setup, compressive loading, analyzed parameters and development of correlations. A lot of techniques are being studied to reduce the effect of the earthquake on structure. The characteristic compressive capacity association of rubberized concrete interlocking masonry wall was studied by Fakih et al. [35].

3.2 Continuation of Research Program

While talking about the earthquake resistant design of buildings, it is very essential to expect or calculate the response and reaction of structures during the earthquake. For this specific determination, different techniques had been adopted all over the world. This research define the method of assembling the interlocking plastic block unit and its structural elements, test setup and instrumentations, analyzed parameters, correlation between compressive strength (compressive capacity) of interlocking plastic block unit and structural elements.

Khan [36] proposed the interlocking plastic block for earthquake resistant house. Plan and 3D view of proposed house and prototype testing is shown in Fig 3.1. The role of material's weight and resulting inertial forces is very crucial in earthquake resistant structures. Interlocking plastic block will have low inertial forces due to their low weight. Inertial forces are generally taken as a systems ability to resist changes caused by some external force (acceleration). The concept is based on Newtons Laws of Motion, including the Law of Inertia and the Action-Reaction Law. In response to such external force, heavy systems (materials) responds more due to their greater weight in comparison with lighter systems (materials), thus causing greater inertial forces. In the design of structures, compressive strength is the most significant parameter and relies primarily on individual unit compressive strength.

Table 3.1: Summarized detail of previous researches on interlocking plastic blocks

Researcher Name	**Main Findings**
Fayaz Khan	Compressive strength of interlocking plastic unit block and prisms, damping ratio and energy dissipation of column against harmonic loading.
Sohail Afzal	Damping ratio, fundamental frequency, acceleration and displacement time histories of interlocking plastic block solid wall and unreinforced brick masonry solid wall against out-of-plane harmonic loading.
Mehran Sudheer	Damping ratio, fundamental frequency, acceleration and displacement time histories of interlocking plastic block wall with window opening and unreinforced brick masonry wall with window opening against out-of-plane harmonic loading.
Hammad Bashir	Acceleration time history, displacement time history and energy absorption of interlocking plastic block structural elements against out-of-plane harmonic loading using numerical approach.
Khurram Shahzad	Energy absorption, acceleration and displacement time histories of interlocking plastic block walls having block return against out-of-plane harmonic loading.

For construction of earthquake resistant housing, the proposed interlocking plastic blocks have base dimension of 150 mm x 150 mm and having four keys at the top.

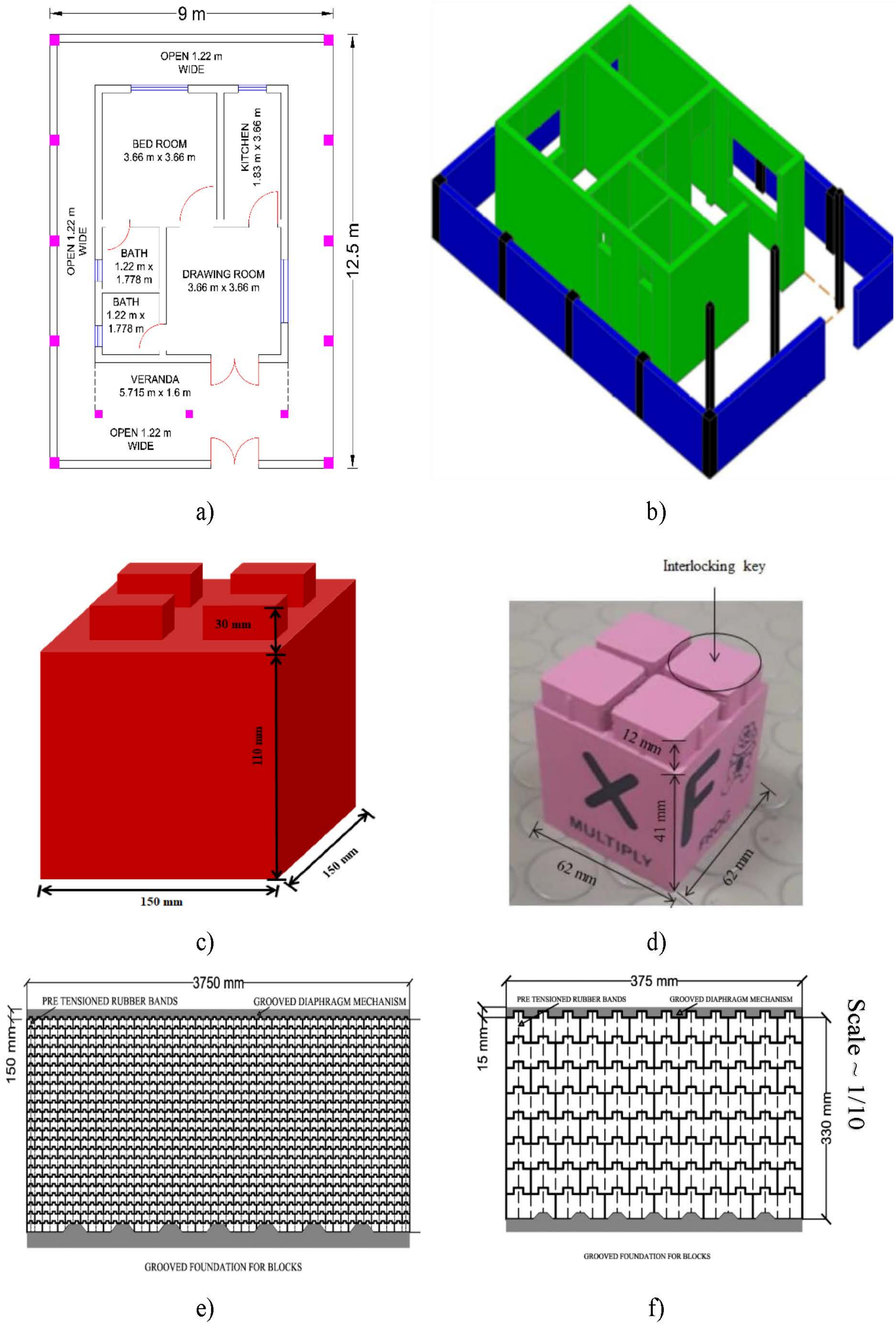


Figure 3.1: Proposed inter-locking plastic-block house: a) plan, b) 3D view c) proposed for construction and d) prototype for current study e) scaled down proposed real wall f) scaled down prototype wall.

Total height of block is 140 mm including the 30mm height of interlocking key as shown in Fig. 3.1(c). Similarly, for prototype construction, the used dimensions in the study are 62 mm x 62mm with a height of 53 mm including the 12 mm height of interlocking key as shown in Fig. 3.1(d). Current research work is continuation of Khan. F [36] research work.

In this study, prototype plastic interlocking block unit and structural elements (prisms with two or three units, column, solid wall, wall with window) are considered for compression testing. Prototype testing [37] [38]serve to provide specifications for a real or proposed working system rather than a theoretical one. Prototype walls scaling and construction technique adopted in this research work is purely based on research practices mentioned in literature Keivan et al. [39]. Outcome of such studies help to understand the behavior of full-scale structures. The primary purpose of current research is to study the correlation between compression strength of interlocking plastic block unit and structural elements. For this, slenderness ratio is an important parameter, which depends on the structure height (UBC-97). That is why; scale down technique is applied mainly on elevation dimension of structural walls. It may be noted that the dimensions of units used in all prototypes (i.e., scaled down column and walls samples) are slightly different. However, the elevation dimensions in both prototypes are approximately the same.

Figure 3.1(e) shows schematic diagram of proposed real interlocking plastic block wall panels. It will have some grooved block mechanism for foundation and roof diaphragm. Figure 3.1(f) shows scaled downed schematic diagram of prototype interlocking plastic block solid wall, using 1/10 scale factor.

3.3 Construction of Prototype Walls

Prototype interlocking plastic block unit, prisms with two and three interlocking plastic blocks, column having eight interlocking plastic blocks making a total height of 330 mm, solid wall consists of forty eight interlocking blocks and wall with opening consists of forty two inter-locking plastic blocks making a total height (H) of 330 mm has been shown shown in Figure 3.2. The wall with opening is having an opening in form of window in the middle. The dimensions of opening are 125 mm x 185 mm. Wooden lintel is provided above the opening for support mechanism. In addition, rubber band are tied up from bottom to top through mid of blocks to provide vertical stiffness in interlocking plastic block units, prisms, column and walls. Rubber band provides integrity of prototype interlocking plastic block structural elements and it also avoids sudden failure of structural elements in terms of buckling. Due to rubber band plastic deformation will increase which ultimately results in greater post-crack energy dissipation and toughness index. Fixed base with the help steel plates is provided. No mass is provided at the wall top. However, the total mass of wall (M) is 1.605 Kg.

3.4 Compression Testing and Instrumentation

3.4.1 Simplified Testing Procedure

Uniaxial compression test is executed on interlocking plastic block unit, prisms having two and three blocks, column, wall panels of solid wall and wall with opening made of interlocking plastic block units. All the interlocking plastic block unit and structural elements are tested in servo-hydraulic testing machine to determine the compressive capacity (σ), corresponding strain (ϵ), modulus of elasticity (E), total compressive toughness T_c. To prevent any local failure of interlocking plastic blocks and to distribute the applied load uniformly, samples are centrally mounted in the servo-hydraulic testing machine and capped at the top and bottom of the face shells by steel plates. For the wall samples, wooden planks are placed at top and bottom to ensure the uniformity of applied load.

The compressive capacity of interlocking plastic block unit and prisms is obtained by using the servo hydraulic testing machine and the test is performed in compliance with the requirement of ASTM D695-02a. The interlocking plastic block unit and prisms are put centrally in the servo-hydraulic testing machine and steel plates are capped at the top and bottom to ensure uniform distribution of applied loads and to prevent any local block failure. The speed of servo-hydraulic testing machine to compress sample is 0.05 in/min until failure. Fig. 3.3 (a,b,c) shows

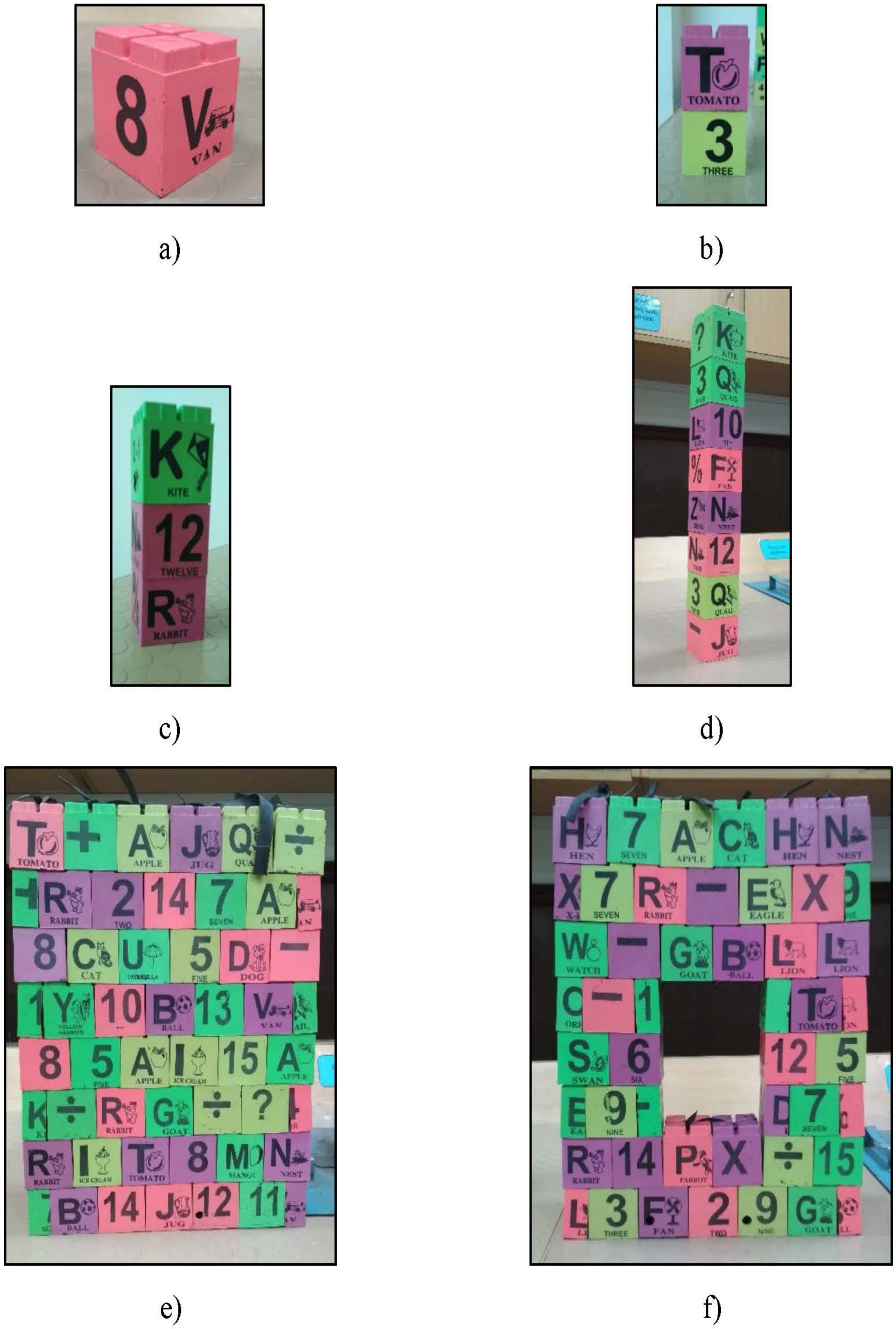


FIGURE 3.2: Protype a) unit block b) prism of two blocks c) prism of three blocks d) column e) solid wall f) wall with opening

the instrumentation of compression test for interlocking plastic block unit, prism having two blocks and prisms having three blocks respectively.

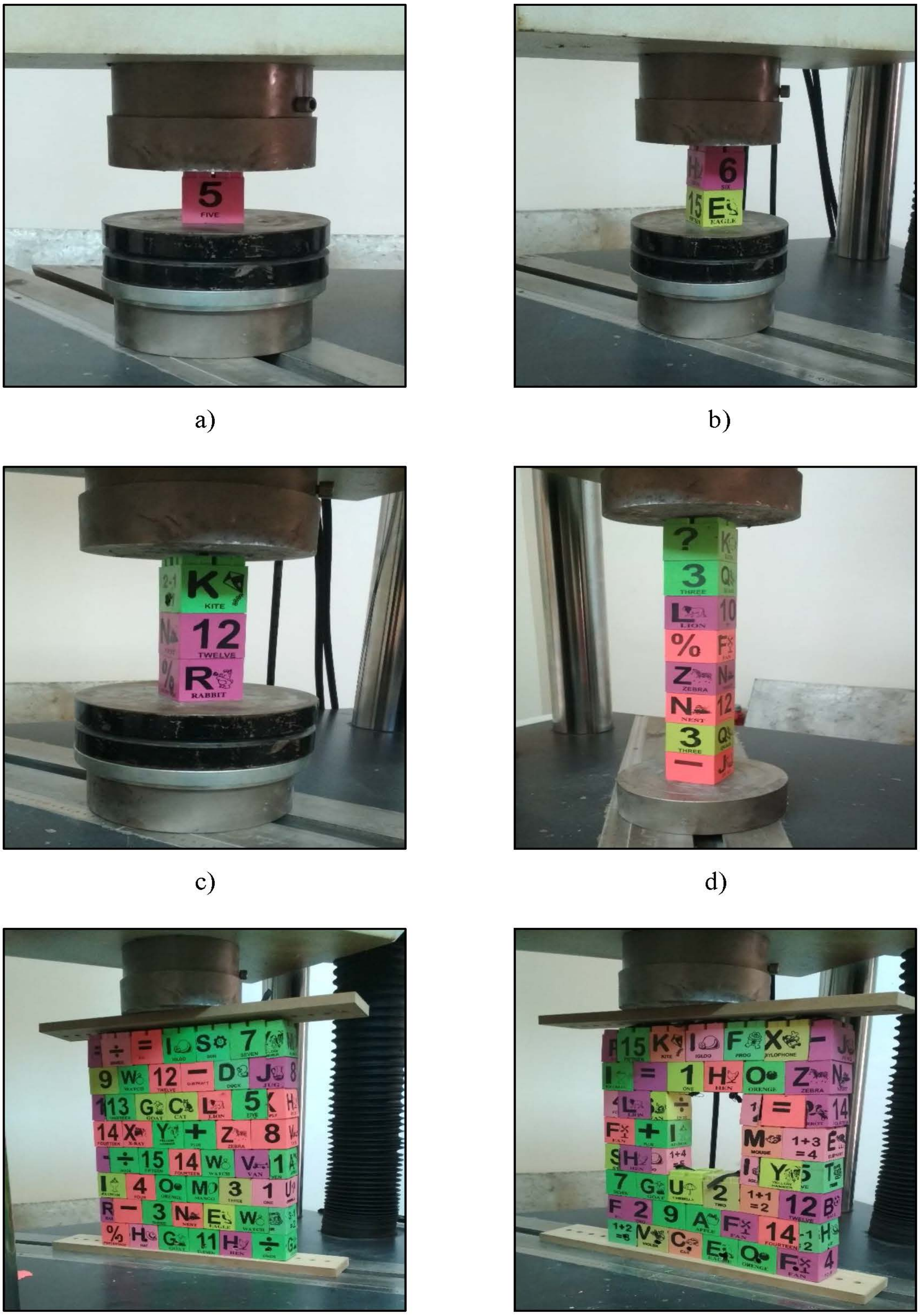
In this study, the test column consisted of eight courses of interlocking plastic blocks with a height equal to the height of wall, as shown in Fig. 3.3 (d). The column of interlocking plastic blocks is made and tested under compressive load, as per the method prescribed in ASTM D695-02a, using servo hydraulic testing machine. The interlocking plastic blocks column put centrally in the servo-hydraulic testing machine and steel plates are capped at the top and bottom to ensure uniform distribution of applied loads and to prevent any local block failure.

The both solid wall and wall with window opening have dimensions of 375 mm length, 330 mm height and 62 mm thickness. The solid wall and wall with opening in the form of window have been made using interlocking plastic blocks in stretcher bond. The stretcher block is the main unit of the wall panel, while the half interlocking plastic block is used to construct the wall course. A wall is made of 08 courses, each containing eight stretchers interlocking plastic blocks (SB) and one-half interlocking plastic block (HB). Wooden lintel is provided above the opening in wall with window opening for support mechanism. Interlocking plastic block solid wall and wall with window opening are capped with steel plate on the bottom and top of the specimen to ensure vertical load distribution uniformly as shown in Fig. 3.3 (e,f). The test is performed in compliance with the ASTM D695-02a specifications. Interlocking plastic block unit and elements labeling are shown in Table 3.2.

3.5 Analyzed Parameters

3.5.1 Analyzed Parameters from Compression Test

Interlocking plastic block unit, prism having two blocks, prism having three blocks, column consisting of six block units, solid wall and wall with opening are tested in a servo-hydraulic testing machine for their maximum peak load carrying capacity, compressive capacity, strain, elastic modulus, total energy absorbed, toughness index. During test load-deformation curves are recorded, which are then converted



a) b)

c) d)

e) f)

Figure 3.3: Experimental test setup; a) unit block b) prism with two blocks c) prism with three blocks d) column e) solid wall f) wall with opening.

TABLE 3.2: Interlocking plastic block unit and elements labeling

Sr. No.	**Interlocking Plastic Block Unit/Element**	**Label**
01	One block	f$_{1b}$
02	Two blocks	f$_{2b}$
03	Three blocks	f$_{3b}$
04	Column	f$_{cb}$
05	Solid wall	f$_{sw}$
06	Wall with opening	f$_{wo}$

to average stress-strain curves for examining interlocking plastic block properties like elastic modulus, energy absorption and toughness index.

3.5.2 Strength Correlation between Individual Block, Prism, Column and Wall Panels

The compressive strength of the wall must be calculated for the construction of the interlocking plastic block wall. There is no code or specification available that compares the compression ability of the interlocking wall of plastic blocks with the compressive ability of the block unit or prism. In this study correlations are developed between the compressive capacity of the interlocking plastic block unit (f$_{1b}$), prism having two blocks (f$_{2b}$), prisms having three blocks (f$_{3b}$), column (f$_{cb}$), solid wall (f$_{sw}$) and wall with opening (f$_{wo}$) in an effort to develop a design code for the interlocking plastic blocks.

Furthermore, the output of the interlocking mechanism is evaluated and the failure mode are tested. All measures of strength used in this analysis are based on the net area. As required by some procedures, depending on the gross area, this can be readily converted into capacity. The capacity relationship result found in this study, however, will not be effected.

3.6 Summary

This chapter discussed the detailed experimental procedure. The prototype interlocking plastic block structure is selected for research work. Plastic interlocking plastic-block is purchased from local market. Prototype interlocking plastic block structure is selected for such type of study to investigate the compressive behavior of structure in material testing laboratories. Integrity of prototype interlocking plastic block structure can be availed by providing rubber band. Stress-strain curve for interlocking plastic-block structure is calculated.

Chapter 4

Experimental Findings

4.1 Background

In previous chapter, experimental procedure is explained in detail. This chapter is about experimental evaluation of the recorded data. Stress strain curves, energy absorption, toughness index and correlation between compressive capacity of interlocking plastic block unit, prisms, column and wall panels are being discussed in this chapter.

4.2 Stress-Strain Curves of Interlocking Plastic Block Unit and its Structural Elements

Load-deformation curves are recorded during experiments, which are then transformed into average stress-strain curves to calculate properties of block. For a unit interlocking plastic block, the maximum load is 2.6 kN and the corresponding deformation is 0.43 mm. For the interlocking plastic block prisms with two and three standard plastic blocks, the peak load is 4.0 kN and 3.1 kN respectively while the corresponding strain is 1.1 mm and 1.1 mm respectively. For the interlocking plastic block column, the peak load is 3 kN and the corresponding deformation is 2 mm. For the interlocking plastic block solid wall and wall with windows opening, the maximum load is 6.8 kN and 3.2 kN respectively while the corresponding

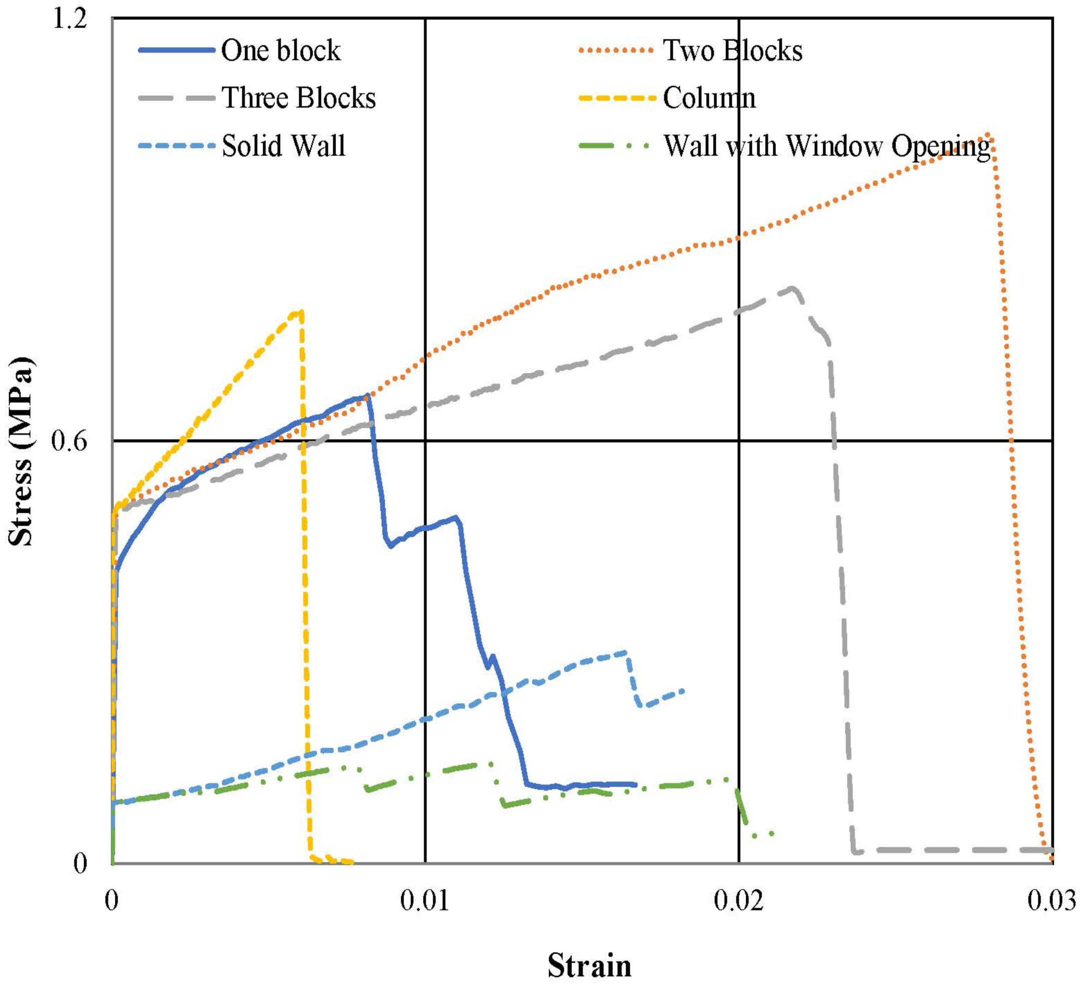
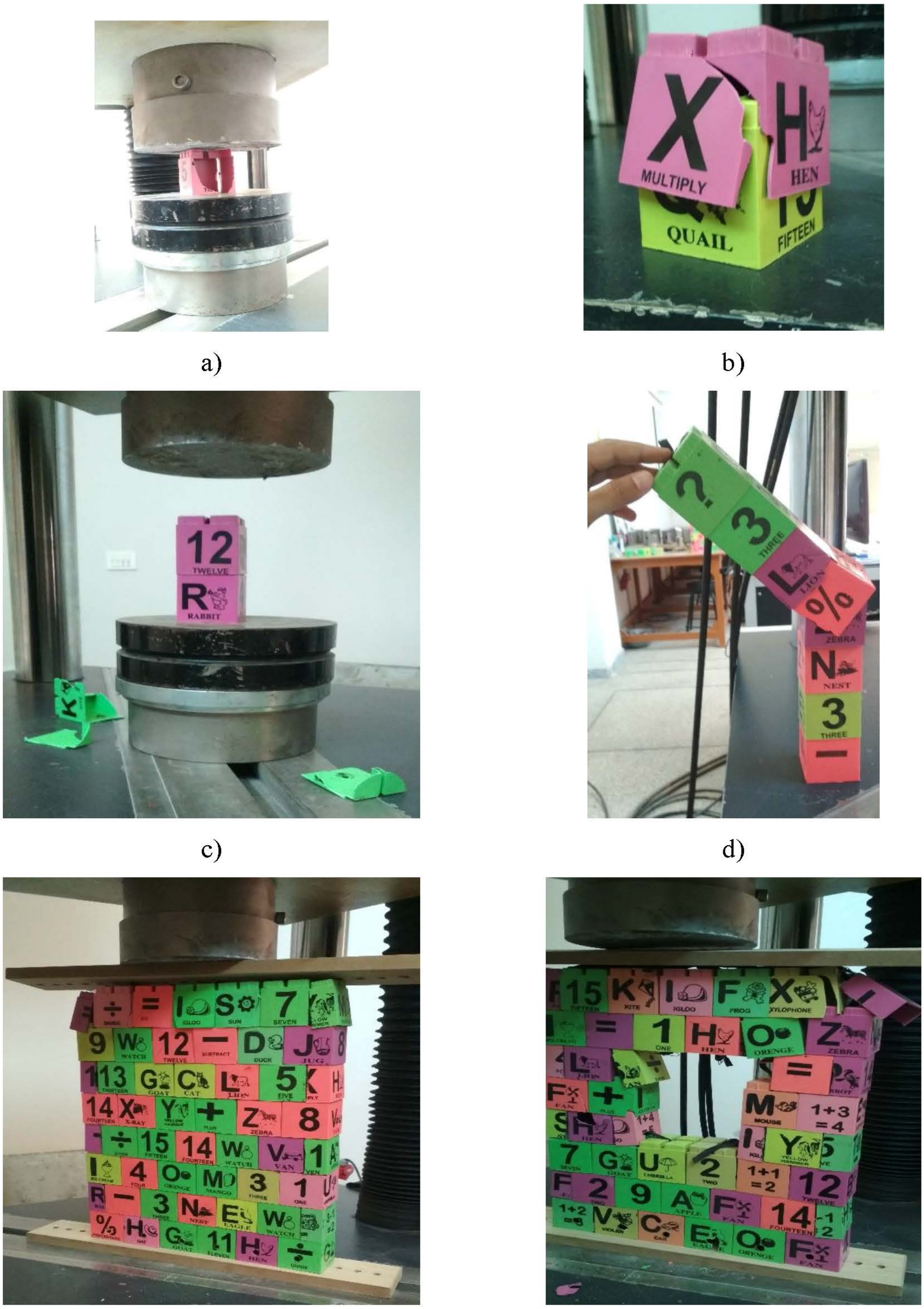


FIGURE 4.1: Stress strain curves of tested specimens

strain is 5 mm and 3.6 mm respectively.

It is observed that cracks are developed in one of the corner of web on the bottom side of the standard block before the ultimate load is reached, propagating upwards. In case of prism having two blocks the crack is developed first in one corner of web of upper block and propagate upward to the flange. The presence of the crack is always on the bottom side of the upper block in one of the corners, but not in the corresponding key. In case of prism having three blocks the crack appeared at one of the bottom corner of upper most block and propagate upward to the flange until the block breaks into parts. In case of column the column buckle from the mid and cracks are observed at the bottom corners of middle block. In case of solid wall cracks are observed in the upper most layer of blocks. In case of wall with window opening the cracks are observed in the corner blocks of upper layer and also in the blocks on which the lintel is resting.



a) b) c) d) e) f)

FIGURE 4.2: Compressive Behavior of ; a) unit block b) prism with two blocks c) prism with three blocks d) column e) solid wall f) wall with opening.

4.3 Energy Absorption and Toughness Index

Capacity of absorption of energy is defined as the amount of energy absorbed per sample unit area in a certain deformation. The toughness index is defined as the ratio of the total area to the area prior to the cracks under the stress-strain curve. The peak load and strain for unit block are 2.6 kN and 8.1*10^{-3} respectively. The compressive capacity of a single interlocking plastic block is 0.7 MPa. Its energy absorption and compressive toughness is 7 x 10^{-3} Nm and 1.5 respectively.

The peak load for prism having two and three blocks is 4 kN and 3.1 respectively. The peak load for prism having three blocks is less than the peak load for prism having two blocks is due to higher slenderness ratio. The compressive capacity of interlocking plastic blocks prism with two and three blocks is 1 MPa and 0.8 MPa respectively. The energy absorption and compressive toughness for the prism consisted of two blocks is is 23 x 10^{-3} Nm and 1.1 respectively. The energy absorption and compressive toughness for the prism consisted of three blocks is is 16 x 10^{-3} Nm and 1.1 respectively.

The compressive strength (compressive capacity) of interlocking plastic block column is 0.8 MPa. Its energy absorption and compressive toughness is 4 x 10^{-3} Nm and 1 respectively. The compressive capacity of interlocking plastic blocks solid wall and wall with window opening is 0.3 MPa and 0.1 MPa respectively. The energy absorption and compressive toughness for the solid wall is is 0.4 x 10^{-3} Nm and 1.1 respectively. The energy absorption and compressive toughness for the wall having window opening is 0.9 x 10^{-3} Nm and 1.7 respectively. The energy absorption of wall with window opening is more as compared to the energy absorption of solid wall because of the larger deformation in wall with opening.

The ability of a material to withstand plastic deformation without rupture is ductility. So, materials having more ductility will have more toughness index. From the results it has been shown that the area under the curve after cracking of interlocking plastic block samples is less, which indicates the brittle behavior of interlocking blocks.

TABLE 4.1: Experimental energy absorption and toughness index values of interlocking plastic block unit and structural elements

Sr. No.	**Structural Unit/Element**	**Peak Load (kN)**	**Stress (σ) (MPa)**	**Strain (ϵ) (10^{-3})**	**Energy absorbed before cracking (E_1) ($10^{-3}Nm$)**	**Energy absorbed after cracking (E_2) ($10^{-3}Nm$)**	**Total Energy absorbed (E_T) (10^{-3})**	**Toughness Index (TI)**
1	One Block	2.6	0.7	8.1	4.7	2.4	7.1	1.5
2	Two Blocks	4	1	28	21.9	1.1	23	1.1
3	Three Blocks	3.1	0.8	21.6	14.2	1.6	15.8	1.1
4	Column	3	0.8	5.9	3.8	0.2	4	1
5	Solid Wall	6.8	0.3	16.3	3	0.4	3.4	1.1
6	Wall with opening	3.2	0.1	12	1.4	0.9	2.3	1.7

4.4 Compressive Strength Correlation between Individual Block, Prisms, Column and Wall Panels

It is noticed that peak load for prism having two interlocking plastic-blocks is 4 kN, which is more than the peak load (2.6 kN) of single interlocking plastic block. The reduction in the peak load of the three-block prism relative to the two-block prism is due to the effect of the interlocking plastic block sample's slenderness ratio (the ratio of height to minimum prism dimension). This correlates well with the fact that the compressive intensity decreases as the sample height increases. The peak load for the the solid wall panel is found to be 6.8 kN which is more than the peak load (3 kN) of column. The peak load for wall is greater than column because of the greater bearing area of wall. The peak load for the the solid wall panel is found to be 6.8 kN which is more than the peak load (3.2 kN) of wall having window opening.

TABLE 4.2: Correlation between peak load capacity of interlocking plastic block unit and structural elements.

Sr. No.	**Structural Unit/Element**	**In terms of**	**Correlation**
1	One Block	–	–
2	Two Blocks	One Block	$f_{2b} = 1.6\ f_{1b}$
3	Three Blocks	One Block	$f_{3b} = 1.2\ f_{1b}$
4	Column	Three Blocks	$f_{cb} = 0.96\ f_{3b}$
5	Solid Wall	Column	$f_{sw} = 2.2\ f_{cb}$
6	Wall with opening	Solid Wall	$f_{wo} = 0.5\ f_{sw}$

The peak load for prism having two blocks is equal to 1.6 of the peak load for the individual block. The peak load for prism having three blocks is equal to 1.2 of the peak load for the individual block. The peak load for the column having eight blocks is equal to 0.96 of the peak load for the prism having three blocks. The peak load for the solid wall panel is equal to 2.2 of the peak load for the column. The peak load for the wall with window opening is equal to 0.5 of the peak load for the solid wall. To sum up the similarity between the individual block, prism, and wall panels, the following similarityis obtained:

where, f_{1b} is the peak load for individual block, f_{2b} is the peak load for prism having two blocks, f_{3b} is the peak load for prism having three blocks, f_{cb} is the peak load for column, f_{sw} is the peak load for solid wall and f_{wo} is the peak load for wall with window opening.

4.5 Summary

In this chapter, experimental evaluation of recorded data is presented. Stress strain curves are evaluated to find energy absorption and compressive toughness of individual interlocking plastic block and its structural elements. Correlations have been developed between compressive strength of individual interlocking plastic block and its structural elements. It is concluded that the peak load for prisms is greater than individual block and also peak load for walls is greater than the peak load of prisms.

Chapter 5

Discussion

5.1 Background

In the previous chapter, experimental evaluation of recorded data, stress strain curves, compressive strength (compressive capacity), energy absorption and compressive toughness is discussed. Relationship between the compressive capacity of standard block unit and structural elements are developed. In this chapter we will discuss interlocking mechanism and failure mechanism of interlocking plastic block unit and structural elements.

5.2 Interlocking Mechanism

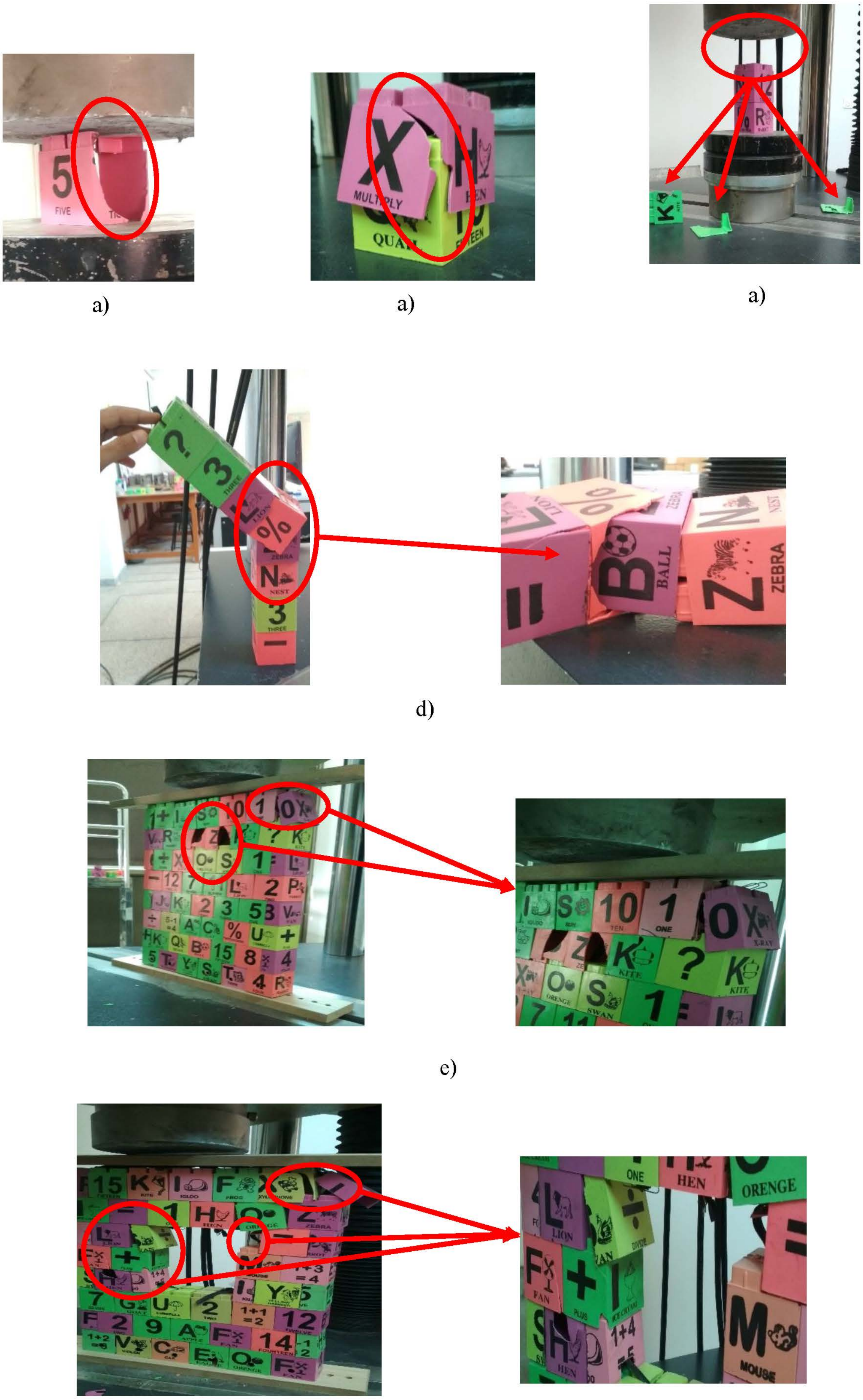
To give the designer a good image of the load transfer process, a comprehensive analysis of the relationship between the various sections of the block under the load applied is required. In the distribution of the stresses generated in the block due to the applied load, the interlocking mechanism plays an important role. It can be observed that through their interlocking keys, there is a connection between the various block units, which in turn led to higher stress levels near the intersection of the shell withweb. The connected parts of the blocks resisted the wall stresses caused by the load applied, incorporating the blocks into the wall. The webs supported lateral resistance to the shells and thus reduced fracture near the intersection of the web-shell and expected severe pressure at these intersections.

5.3 Failure Mechanism

For the standard interlocking plastic block unit, when the load exceeds the peak value of interlocking plastic block unit there is a brittle failure of block in the form of splitting of block into parts. In case of prisms having two and three unit blocks respectively, maximum stresses are developed in the upper block causing cracks initially at bottom corners of block and finally splitting of the block. In case of column, failure is observed in the form of cracks in the middle block and buckling of the column in the middle. Rubber band provided in the column to tie the interlocking plastic blocks and to provide the vertical stiffness, helps to hold the blocks together.

Similar to the prism specimens, the failure of the solid wall panel is observed as the development of vertical cracks in the blocks shells of the upper layer especially in the blocks at the corner due to the development of stresses in the shells. The cracks in the shells are vertical and aligned with the vertical joints. For the wall with window opening the failure is caused due to the development of vertical cracks in the shells of blocks on the which the lintel is resting. Window opening in the wall causes more plastic deformation in wall with opening as compared to solid wall.

Test results obtained from the compression test show the interlocking block approach has the ability to be adopted in building or housing construction. However, additional tests are required before the device can be implemented for full commercial applications. It is important to research the effects of slenderness ratio, eccentric and lateral loads, wall openings and vertical and horizontal relations on the strength of the wall. The role of the interlocking keys in combining the wall can be explored in these further studies.



a) a) a)

d)

e)

f)

Figure 5.1: Crack pattern of interlocking plastic; a) one block b) two blocks c) three blocks d) column e) solid wall f) wall with opening.

5.4 Summary

In this chapter the interlocking plastic block mechanism and its failure mechanism has been discussed. The interlocking mechanism plays an important role in the occurrence of the stresses generated in the block due to the load imposed. The failure phase of the prisms and wall panels is due to stress generation in the networks. Additionally, vertical cracks are formed in the block shells with an increase in the load applied.

Chapter 6

Conclusion and Future Work

6.1 Conclusions

Many earthquake resistant construction techniques are available in literature for earthquake prone areas. But these are uneconomical. Developing countries can not afford such techniques to lessen the earthquake damages. In this pilot study, compressive behavior of interlocking plastic block unit and its structural elements is compared. Prototypes of interlocking plastic block unit, prisms consisted of two and three standard blocks, column, solid wall and wall with opening are tested under compressive loading to determine the compressive strength (compressive capacity), energy absorption and compressive toughness. Compressive strength correlations have been developed between individual interlocking plastic block and its structural elements. Following conclusions can be drawn from this research work:

- The interlocking block keys bind the blocks to a solid wall and can remove the mortar layers used for traditional masonry construction.
- The failures are due to the growth of cracks in the lower corners of the shells. Additionally, vertical cracks formed in the block shells with an increase in the load applied. The cracks are vertical and aligned in the shells with the vertical joints.

- The peak load carrying capacity for interlocking unit block is less than multiple blocks (prisms) as observed by Khan [36]. The peak load carrying capacity of column (having eight block units) is less than prisms (having two and three unit blocks), it may be due to high slenderness ratio of column as compared to prisms. The peak load carrying capacity of solid wall and wall with window opening is greater than peak load carrying capacity of column, it is because wall panels has more bearing area as compared to column.

- The correlations among the compressive capacity of unit block, prisms, column, solid wall and wall with window opening had been established, enabling an estimate of the prisms compressive capacity based on the unit block's compressive capacity and estimate of the walls compressive capacity base on the column compressive capacity.

- As the weight and area of interlocking plastic solid wall is 1.605 kg and 0.02325 m^2 respectively, so the compressive stress of wall due to its weight is 69 x 10^{-4} MPa which is much less than its compressive capacity (0.3 MPa). So, if we adopt the interlocking plastic blocks for the walls of proposed house then the compressive capacity of the walls is enough to carry the compressive stress (due to its weight) acting on them.

6.2 Future Work

Before the block can be adopted for application in practical life, it is important to investigate the effects of slenderness, eccentric and lateral loads, horizontal connectionsand effect ofdiaphragm on the wall strength.

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